

THE DIET OF *BARBUS CALLENSIS* (CYPRINIDAE) IN NORTHERN TUNISIA

by

M.M. KRAIEM (1)

ABSTRACT. - Qualitative and quantitative aspects of the diet of *Barbus callensis* Valenciennes, 1842 as well as its feeding rhythm, were investigated. Food varied according to the size and age of the fish, to the composition of the invertebrate fauna and to the hydrological phases of the biotopes. Young barbel ate algae and microzoobenthos, mostly larvae of Chironomidae and Simuliidae. Older specimens fed on larger benthos, such as larvae of Ephemeroptera and Trichoptera and on plant fragments; they captured small fishes when benthos became scarce. *B. callensis* fed during the day. In young specimens this activity was lower during the winter, presumably because of low temperature and floods. In adults, feeding decreased in spring during the spawning period, when the fishes might even fast completely.

RÉSUMÉ. - Cette étude porte sur l'analyse qualitative et quantitative du régime alimentaire de *Barbus callensis* Valenciennes, 1842 ainsi que sur son rythme alimentaire. *B. callensis* présente un régime alimentaire diversifié qui varie avec la taille et l'âge du poisson, ainsi qu'avec la composition faunistique et les caractères hydrologiques du milieu. *B. callensis* est micro-zoo-benthophage à l'état jeune et devient benthophage en vieillissant. Les larves de Chironomidae et de Simuliidae constituent les proies essentielles du régime alimentaire des jeunes barbeaux, les larves de Trichoptera et d'Ephemeroptera et les débris végétaux sont les proies dominantes dans l'alimentation des barbeaux âgés qui deviennent même ichthyophages en l'absence de benthos. *B. callensis* présente, en outre, une activité alimentaire essentiellement diurne; cette activité diminue en hiver pour les jeunes barbeaux (sans doute à cause des faibles températures de l'eau et des crues). Chez les individus adultes, cette baisse de prise alimentaire se fait sentir au printemps (période de frai); pendant cette période on assiste même à un jeûne de ces poissons.

Key-words. - Cyprinidae, *Barbus callensis*, Tunisia, Oued, Reservoir, Diet.

Barbus callensis is a cyprinid fish widely encountered in Tunisian rivers (Kraïem, 1983). Given its abundance, it represents a key component of the ecosystem (Kraïem *et al.*, 1986) and an important link in the trophic chain. Here, the aim is to study the feeding pattern of this species in three different biotopes in the north of Tunisia (Fig. 1): Oued Ghezala in the west, a fairly productive mountain stream; Oued Sejnane in the east, a stream that flows in a plain, is characterized by a low productivity (Kraïem, 1987), and flows into the brackish Lake Ichkeul; and Sidi Salem impoundment located on Oued Merjerda in the north, the largest Tunisian reservoir, which shows increasing eutrophication since its filling up.

Our aim was to investigate fish feeding patterns in relation to fish size, as well as the nycthemeral and seasonal rhythms of their feeding activity in each of these three biotopes.

(1) Laboratoire d'Hydroécologie, Faculté des Sciences de Tunis, Campus Universitaire, 1060 Tunis, TUNISIE.

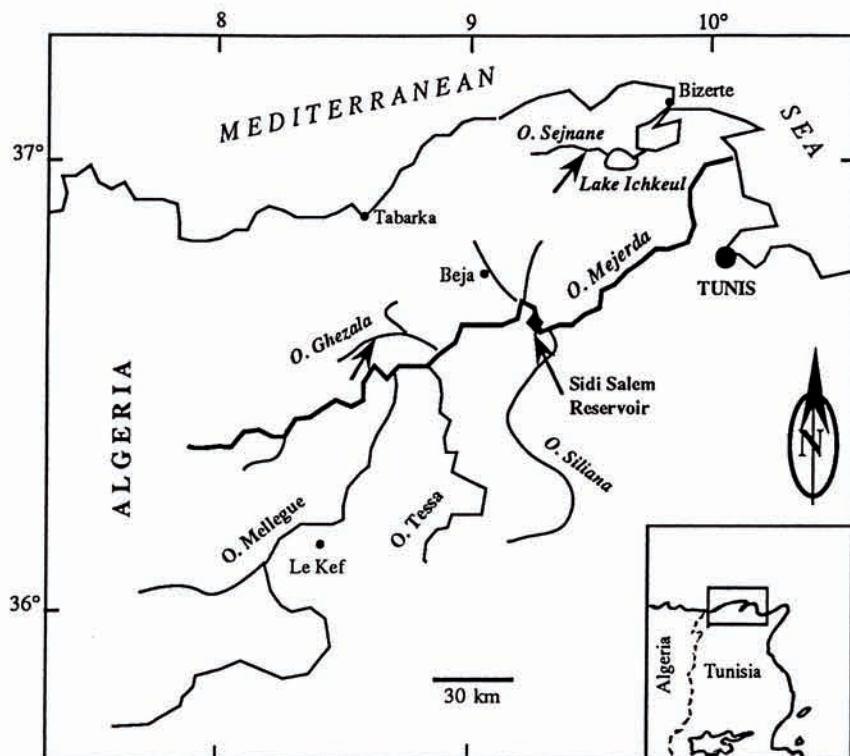


Fig. 1. - Location of the streams and sites (arrows).

MATERIAL AND METHODS

Material

During our electric fishing (by E.P.M.C. gear) carried out from 1983 to 1989, we examined 338 *Barbus callensis* for this study. Details are given in table I.

All fish used for this study were killed by immersion in a narcotic solution of MS. 222 right after capture, and measured (total length: TL). The complete digestive tract of adults was dissected and individually preserved in flasks containing a 5% formalin solution to stop digestive processes. Young fishes were preserved whole.

Contents of the digestive tract between the oesophagus and the first intestinal curve (the "stomach bulb", Kraïem, 1980), were investigated. Fragmented prey were identified by reference to intact benthos taken on the same day and in the same biotope using a Surber net with 0.5 mm meshes. Benthos was estimated in the following classes of relative abundance per 0.1 m² in order to compare it to the food spectrum of the barbel studied.

1 = mean of 1 specimen; 2 = mean of 2 to 5 spms; 3 = mean of 6-10 spms; 4 = mean of 11-15 spms; 5 = mean of 16-20 spms; 6 = mean of 21-30 spms; 7 = mean of 31-50 spms; 8 = mean of 51-75 spms; 9 = mean of 76-100 spms; 10 = mean of > 100 spms.

Methods

Following the inventory of stomach contents, each prey item was isolated, identified and counted. Three indices described by Hynes (1950) were computed from the raw data:

$$\text{- Percentage of occurrence: } OC \% = \frac{n}{N} \times 100$$

with n = number of stomachs containing a given prey; N = total number of full stomachs.

$$\text{- Percentage of numerical frequency (or relative abundance): } N \% = \frac{NP}{NT} \times 100$$

with NP = number of individuals in a prey item; NT = total number of individuals including all items.

$$\text{- Volume percentage: } V \% = \frac{VP}{VT} \times 100$$

with VP = volume of a prey item; VT = volume of all consumed prey.

The simultaneous application of these indices to the same sample makes it possible to draw a good picture of the feeding pattern. They take into account fish feeding preferences (occurrence) as well as the relative quantity of prey consumed (numerical frequency and volume percentage).

In order to adequately compare the importance of a prey category in the feeding pattern of barbel of different sizes, we used the Feeding Index (F.I.) of Lauzanne (1975), which takes into account both occurrence and prey volume:

$$F.I. = \frac{\% OC \times \% V}{100}$$

This index ranges from 0 to 100. When values were < 10 , prey were termed rare. When they were between 10 and 25, prey were occasional; when they were between 25 and 50, prey were essential; beyond value 50, prey were largely dominant.

Table I. - Numbers and categories (according to total length, TL) of *Barbus callensis* used in this study. For the sample of young barbels (Y): $4 < TL \leq 13$ cm; for the adults (A): $14 \text{ cm} \leq TL \leq 30$ cm.

Topics studied		O. Ghezala	O. Sejnane	Sidi Salem
Sampling dates		6 Jul.1984 23 Nov.1984 28 Jan.1986 7 May 1986 16-17 Jul.1987	19 Jan.1987 25 May 1987	10 Jul.1989
Food spectrum in relation to size	qualitative study	41 (17 Y + 24 A)	44 (18 Y + 26 A)	- -
	quantitative study	41 (17 Y + 24 A)	- -	38 (16 Y + 22 A)
Nycthemeral and seasonal rhythms		216	40 (25 Y + 15 A)	-
Total number (338)		216	84	38

The feeding activity of barbel was analysed by a vacuity index (Hynes, 1950).

$$V.I. = \frac{ES}{TS} \times 100$$

with ES = number of empty stomachs; TS = total number of stomachs examined.

RESULTS

Feeding pattern of *Barbus callensis*

Qualitative aspect (% of barbel containing a food item)

Young barbel contained a small number of taxa (6 taxa), represented almost exclusively by small animal prey and microscopic algae (Figs 2, 3). The animal components included many Diptera (Chironomidae, and Simuliidae or Culicidae) and Ephemeroptera larvae. In contrast, adult barbel contained more prey species (11 taxa) including larger animal and vegetable components, insect larvae of the orders Diptera, Ephemeroptera and Trichoptera and plant fragments being preferred (Figs 2, 3).

Table II. - The invertebrate benthic fauna of Oued Ghezala.

Taxa		Abundance classes
Plathelminths	Triclad	
	<i>Dugesia subtentaculata</i> (Draparnaud, 1801)	2
Nemathelminths	Nematoda	6
Annelida	Oligochaeta	
	Lumbricidae	5
	Achaeta	
	Glossiphoniidae	2
Arachnida	Hydracarinae	4
Crustacea	Decapoda	
	<i>Aryaephyra desmaresti</i> (Millet, 1831)	2
	<i>Potamon edule</i> (Latreille, 1818)	1
Insecta	Odonata	1
	Heteroptera	
	Gerridae	2
	Hydrometridae	2
	Coleoptera	
	Elmidae	2
	Ephemeroptera	
	Baetidae	
	<i>Baetis pavidus</i> (Grandi, 1949)	5
	<i>Baetis rhodani</i> (Pichet, 1848)	3
	Caenidae	
	<i>Caenis luctuosa</i> (Burneister, 1839)	8
	Leptophlebiidae	
	<i>Choroterpes picteti</i> (Eaton, 1781)	6
	Heptageniidae	
	<i>Ecdyonurus rotschildi</i> (Navas, 1929)	7
	Plecoptera	
	Setipalpa	
	<i>Afroperlodes</i>	2
	Trichoptera	
	Rhyacophilidae	
	<i>Rhyacophila munda</i> (Mc Lachlan, 1862)	3
	Hydropsychidae	
	<i>Hydropsyche pellucidula</i> (Curtis, 1834)	5
	<i>Hydropsyche punica</i> (Malicky, 1981)	4
	Diptera	
	Chironomidae	10
	Simuliidae	9

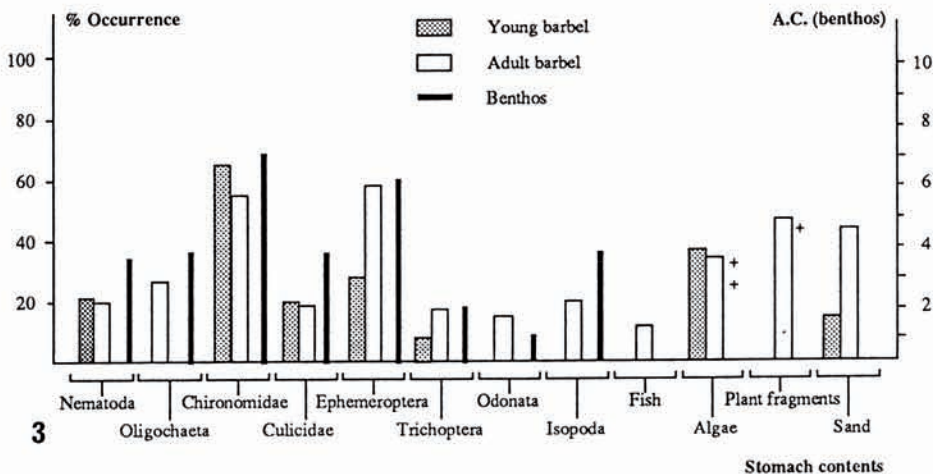
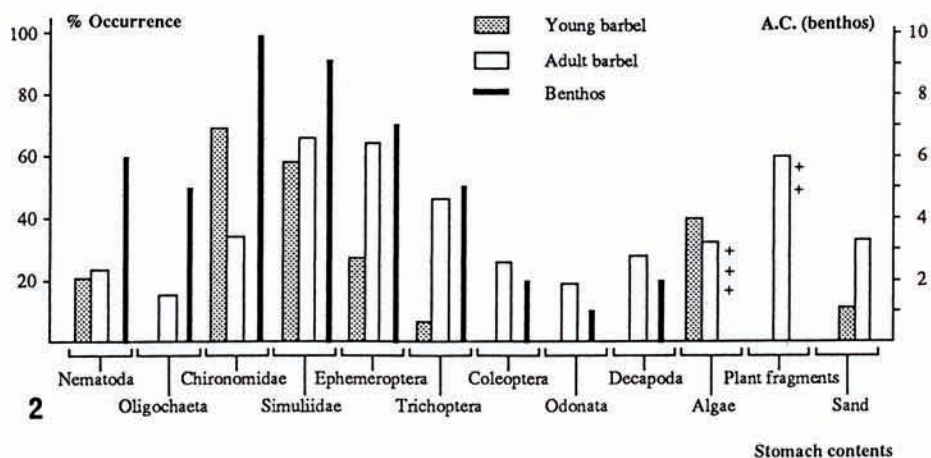


Fig. 2. - Food spectrum of young and adult *Barbus callensis* and abundance classes (A.C.) of the benthic fauna in Oued Ghezala on 6 July 1984.

Fig. 3. - Food spectrum of *Barbus callensis* and abundance classes (A.C.) of the benthic fauna in Oued Sejnane on 14 November 1984.

The food spectra of Oued Ghezala and Oued Sejnane barbel do not exactly reflect the composition of the benthic fauna of these two streams. Certain taxa present in the benthos, such as larvae of Plecoptera and Heteroptera, Triclad and Hirudinae in Oued Ghezala, larvae of Heteroptera and Coleoptera, Gastropoda and Amphipoda in Oued Sejnane, were missing in the stomach contents (Tables II, III). However, the animal prey most consumed by young and adult barbel in both streams were also the most dominant taxa in the benthos. On the other hand, in Oued Sejnane where benthic fauna is less abundant and influenced by the proximity to the sea (Kraïem, 1987), barbel consumed taxa of brackish origin (Isopoda: *Idotea* and *Sphaeroma*) and even became piscivorous in unfa-

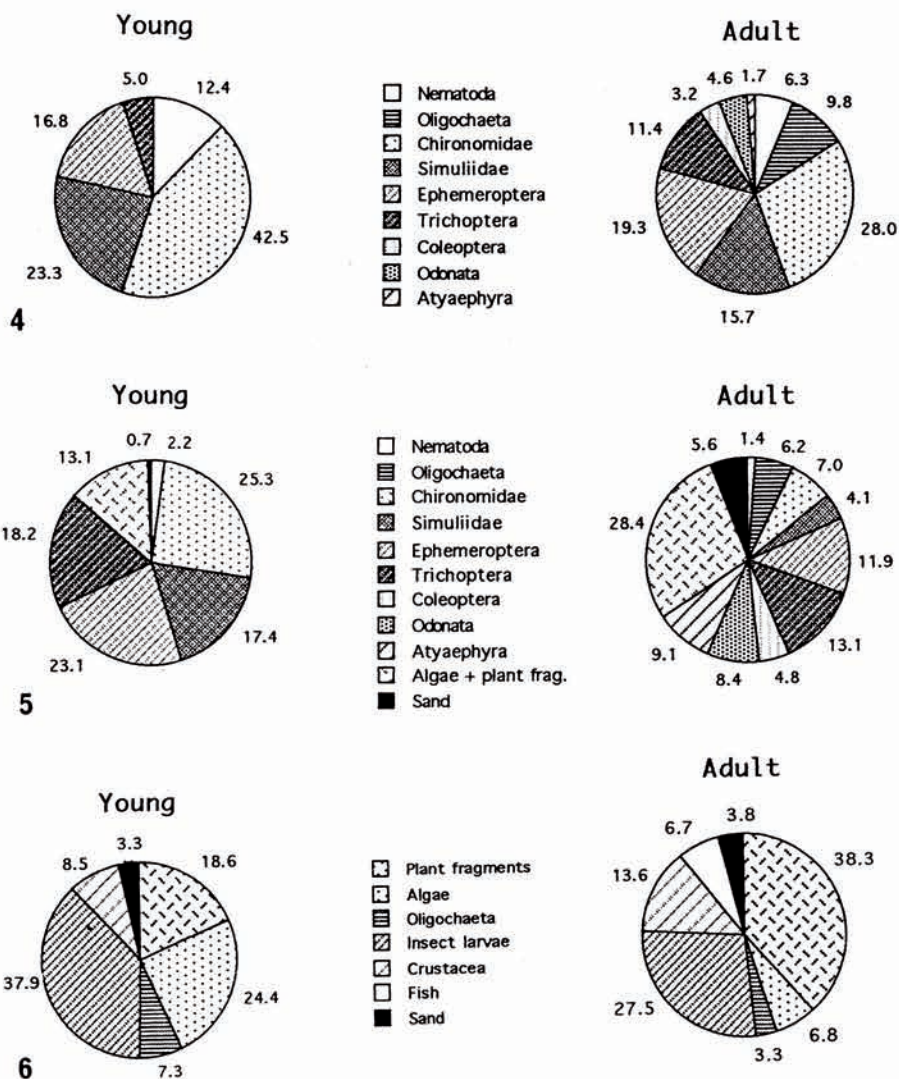


Fig. 4. - Numerical percentage of animal prey found in young and adult *Barbus callensis* caught in Oued Ghezala on 6 July 1984.

Fig. 5. - Volumetric percentage of prey found in young and adult *Barbus callensis* caught in Oued Ghezala on 6 July 1984.

Fig. 6. - Volumetric percentage of prey found in young and adult *Barbus callensis* caught in Sidi Salem reservoir on 10 July 1989.

favourable conditions when benthos was scarce and insufficient. This means that there was no real prey selection: the barbel consumed what they found on the bottom of the biotope. In most stomachs, especially in adult barbel, there were sand grains.

Quantitative aspect

This aspect was analysed using two indices: the numerical frequency of prey eaten by barbel (the vegetable component was not taken into account, given the difficulty of its estimation) and the volume of each food item in the stomach content.

Food spectrum of young barbel. - In Oued Ghezala, the prey most consumed by young barbel were in the following decreasing order: larvae and nymphs of Diptera (Chironomidae and Simuliidae), larvae of Ephemeroptera, Nematoda, and larvae of Trichoptera (Fig. 4). These prey were small and mostly insect larvae. In volumetric percentage (Fig. 5), Diptera larvae (Chironomidae and Simuliidae) represented the largest fraction of the food spectrum of young barbel, followed by Ephemeroptera and Trichoptera larvae; a fairly high percentage of microscopic algae came next; and finally, nematodes represented a very small fraction of the food spectrum despite their fairly high numerical frequency. The animal fraction (86.5%) was distinctly larger than the vegetable fraction (13.1%).

In Sidi Salem reservoir the animal and vegetable components of the food spectrum were nearly equal; however the animal fraction was slightly larger (57% versus 43%) (Fig. 6). This spectrum was also dominated by insect larvae, followed in decreasing order of volume percentage by the vegetable component with its two items (algae and plant fragments), the Crustacea and the Oligochaeta.

Table III. - The invertebrate benthic fauna of Oued Sejnane.

Taxa		Abundance classes
Nematoda		4
Annelida (Oligochaeta)	Naididae	4
	Enchytraeidae	2
	Lumbriculidae	4
Crustacea	Amphipoda	
	<i>Gammarus aequicauda</i> Martynov, 1931	2
	Isopoda	
	<i>Sphaeroma ephippium</i> Costa, 1882	4
	<i>Idotea chelipes</i> (Pallas, 1766)	2
Insecta	Odonata	
	Agrionidae	2
	Libellulidae	1
	Heteroptera	
	Corixidae	3
	Gerridae	3
	Coleoptera	
	<i>Ochthebius exaratus</i> Mulsant, 1844	2
	Ephemeroptera	
	<i>Baetis pavidus</i> (Grandi, 1949)	5
	<i>Caenis luctuosa</i> (Burneister, 1939)	6
	<i>Ecdyonurus rotschildi</i> (Navas, 1929)	4
	<i>Choroterpes picteti</i> (Eaton, 1781)	4
	<i>Cloeon dipterum</i> Linné, 1761	3
	Trichoptera	
	<i>Hydropsyche maroccana</i> Navas, 1935	2
	<i>Hydropsyche resmineda</i> Malichy, 1977	2
Diptera		
	Chironomidae	7
	Culicidae	4
Mollusca	Lamellibranchia	

Food spectrum of adult barbel. - In Oued Ghezala the animal component of the food spectrum of adult barbel was essentially dominated by insect larvae of the orders Ephemeroptera and Diptera (Chironomidae and Simuliidae), followed, in decreasing order, by Trichoptera larvae, Oligochaetes, Nematodes, Odonata larvae, Coleoptera larvae, and finally the Crustacea *Athyaeephyra* (Fig. 4). The volumetric representation (Fig. 5) of this spectrum shows that the animal component dominated the vegetable component (66% versus 28.4%). On the other hand, large-sized animal prey (larvae of Trichoptera, Ephemeroptera and Odonata, and *Athyaeephyra*) dominated over the small-sized ones, which ranked in a decreasing order of volume percentage as follows: Oligochaeta, Insect larvae of Diptera (Chironomidae and Simuliidae), Coleoptera and finally Nematoda, which represented a minute fraction to the food spectrum. Nevertheless the vegetable component, essentially composed of plant fragments with a small fraction of microscopic algae, was fairly abundant among adult barbel.

In Sidi Salem reservoir as for young barbel, the adults show similar proportions between the animal and vegetable components of the food spectrum (51.1% versus 45.1%) (Fig. 6). Here, the plant fragments dominated; they were followed, in decreasing order, by Insect larvae, Crustacea, Algae, Fishes and Oligochaetes. The vegetable component consisted of algae for the young barbel, and of plant fragments for the adults.

Importance of prey in the feeding pattern. - The analysis of the feeding index (Table IV) shows that the dominant food organisms of young barbel were insect larvae of the orders Diptera (Chironomidae and Simuliidae) and Ephemeroptera, and microscopic algae; the occasional prey were Trichoptera larvae of and the rare prey were Nematodes.

Prey	Young barbel 4 < TL ≤ 13 cm	Adult barbel 15 < TL ≤ 30 cm
Nematoda	4.5 Rare	3.2 Rare
Oligochaeta	-	9.5 Rare
Chironomidae (larvae)	86.6 Dominant	11.1 Occasional
Chironomidae (pupae)	17.5 Occasional	10.2 Occasional
Simuliidae	71.0 Dominant	27.3 Essential
Ephemeroptera	62.3 Dominant	77.8 Dominant
Trichoptera	12.0 Occasional	60.4 Dominant
Coleoptera	-	12.9 Occasional
Odonata	-	16.1 Occasional
Decapoda	-	21.2 Occasional
Algae	54.7 Dominant	7.3 Rare
Plant fragments	-	88.5 Dominant

Table IV. - Feeding index and importance of prey consumed by *Barbus callensis*. (Sample from Oued Ghezala, 6 July 1984).

In contrast, dominant prey of adult fish consisted of insect larvae of Ephemeroptera and Trichoptera, and plant fragments. Larvae of Diptera (Simuliidae) were essential prey.

The decapod (*Athyaephyra*) and insect larvae of Odonata, Coleoptera and Diptera (Chironomidae) were occasional prey. Finally rare prey were represented by the Nematodes.

Feeding rhythm of *Barbus callensis*

Nycthemeral variations of feeding activity

The analysis of the contents of the digestive tract of *B. callensis* immediately after its capture in Oued Ghezala shows that stomachs were full during the day (from 10 h to 18 h) and almost empty at night (from 21 h to 4 h) (Table V). This illustrates an essentially diurnal feeding activity.

Seasonal variations of the feeding activity

In Oued Ghezala the feeding activity of young barbel decreased in winter, given the noticeable fall in water temperature and its high turbidity caused by the floods (Table VI). It can be noted also that feeding among adult barbel was low or non-existent in spring which corresponds to their spawning season. This was confirmed in Oued Sejane after two fishing sessions, one in January and the other in May 1987. In fact, 21 out of the 25 young barbel caught on 19 Jan. 87 had completely empty stomachs; that day the stream was overflowing and very turbid. The 15 adults caught on 25 May 87 had empty or almost empty digestive tracts.

DISCUSSION AND CONCLUSIONS

The present study shows that the feeding pattern of *Barbus callensis* is fairly diverse and dominated by animal prey. The size of the prey consumed increases with the age and the size of the fish. Young barbels seem to feed exclusively on small food items. They have a feeding pattern that is rather algivorous and micro-zoobenthivorous. With an increase in size, they become benthivorous, with a dominance of animal prey. When there is a lack of benthos, the adults even become piscivorous, as also observed for *B. barbus* in Romania (Gyurko and Nagy, 1964).

Table V. - Stomach contents of *Barbus callensis* immediately after capture. (Samples taken in Oued Ghezala on 16 and 17 July 1987).

Stomachs	12 h	15 h	18 h	21 h	4 h	7 h	10 h
Full	8	9	6	3	2	4	7
Half full	5	4	5	6	7	7	5
Empty	0	0	1	3	3	1	0
Total (86)	13	13	12	12	12	12	12

REFERENCES

- ADAMEK Z. & P. OBRDLIK, 1977. - Food of important Cyprinid species in the warmed barbel-zone of the Oslava River. *Folia Zool.*, 26(2): 171-182.
- CRAIG J.F., 1977. - Seasonal changes in the day and night activity of adult perch, *Perca fluviatilis* L. *J. Fish Biol.*, 11: 161-166.
- GYURKO S. & Z. NAGY, 1964. - Dinamica nutritivă la Mreana (*B. barbus* L.) din râul Mures. *Studii si Cercetari*, 3(6): 169-180.
- HYNES H.B.N., 1950. - The food of freshwater sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*), with a review of methods used in studies of the food of fishes. *J. Anim. Ecol.*, 19: 36-58.
- KRAIEM M.M., 1980. - Structure et fonctionnement des écosystèmes du Haut-Rhône français. XXI. Contribution à l'étude du régime alimentaire de *Barbus barbus* (L., 1758) (Poissons, Cyprinidae). *Bull. fr. Pisc.*, 278: 1-10.
- KRAIEM M.M., 1983. - Les poissons d'eau douce de Tunisie. Inventaire commenté et répartition géographique. *Bull. Inst. natl. scient. techn. Océanogr. Pêche Salammbô*, 10: 107-124.
- KRAIEM M.M., 1986. - Contribution à l'étude hydrobiologique de trois cours d'eau du nord-ouest de la Tunisie: présentation, physico-chimie et aperçu faunistique. *Bull. mens. Soc. linn. Lyon*, 53(3): 96-104.
- KRAIEM M.M., 1987. - Contribution à l'hydrobiologie du réseau hydrographique de l'Ichkeul (Tunisie septentrionale). *Archs. Inst. Pasteur Tunis*, 64(4): 463-475.
- KRAIEM M.M., BOUVET Y., PATTEE E. & H. PERSAT, 1986. - Etude des populations de barbeaux, *Barbus callensis* Valenciennes 1842, dans trois cours d'eau du nord-ouest de la Tunisie. *Arch. Hydrobiol.*, 107: 411-422.
- LAUZANNE L., 1975. - Régime alimentaire d'*Hydrocyon forskalii* dans le lac Tchad et ses tributaires. *Cah. ORSTOM, Hydrobiol.*, 9(2): 105-121.
- LAUZANNE L., 1988. - Les habitudes alimentaires des poissons d'eau douce africains, pp. 221-242. In: *Biologie et Ecologie des Poissons d'Eau douce africains* (Levêque C., Bruton M.N. & G.W. Ssentongo, eds). ORSTOM éd., Paris.
- LIND E.A., ELLONEN T., KERANEN M., KUKKO O. & A. TENHUNEN, 1973. - Seasonal variation in the diurnal periodicity of activity of the perch, *Perca fluviatilis* L. *Kalamies*, 3: 1-6.
- LOBON-CERVIA J. & A. De DIEGO, 1988. - Feeding strategy of barbel (*Barbus bocagei* Steind.) with relation to benthos composition. *Arch. Hydrobiol.*, 114(1): 83-95.
- NEVEU A., 1979. - Les problèmes posés par l'étude de l'alimentation naturelle des populations sauvages de poissons. *Bull. Cent. Etud. Rech. sci. Biarritz*, 12(3): 501-502.
- POLLING L., SCHOONBEE H.J. & J.E. SAAYMAN, 1992. - Feeding habits of two small cyprinids, in a subtropical impoundment in the Transvaal, South Africa. *Rev. zool. afr. Belg.*, 106(3): 243-252.

Reçu le 25.04.1995.

Accepté pour publication le 30.08.1995.